

MORPHOLOGICAL INTERGRADATION OF VARIETIES OF *BIDENS ARISTOSA* (COMPOSITAE) IN NORTHERN ARKANSAS

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Bidens polylepis Blake (Compositae) is a widespread, fall-blooming, herbaceous perennial of low ditches and waste ground in the eastern United States. It was described by Nuttall (as *Coreopsis involucrata*) in 1834. It is very similar to *B. aristosa* (Michx.) Britton, another widespread species of similar range, differing (purportedly) from *B. aristosa* in its more numerous, larger, and coarsely pubescent outer phyllaries (those of *B. aristosa* few, small, and nearly glabrous) and its narrower achenes. The two species include parallel varieties.

While several authors have expressed doubts as to the relative distinctness of *Bidens polylepis* and *B. aristosa* (e.g., Cronquist, 1952; Steyermark, 1963; Smith, 1973), *B. polylepis* has been treated at the species level by taxonomists (including the latest authority on the genus; Sherff, 1937) until very recently. Wunderlin (1972) formally proposed that *B. polylepis* be reduced to a variety of the older *B. aristosa*, as *B. aristosa* (Michx.) Britt. var. *retrorsa* (Sherff) Wunderlin, a reduction that seemed perfectly reasonable to the present authors. Wunderlin, however, made the new combinations without presenting supporting data. Intergradation between *B. aristosa* var. *aristosa* and var. *retrorsa* had been noted informally by the authors in Arkansas and Texas material. A study of this intergradation in populations of *B. aristosa* in northern Arkansas was undertaken with the intention of providing formal supporting data for Wunderlin's combinations.

MATERIALS AND METHODS

Two populations of *Bidens aristosa* in northern Arkansas were selected for study. Each population included several hundred individuals. Population I was located in Fayetteville, Washington County, in northwestern Arkansas, one and one-half miles west of jct. US 71 bypass & highway 16 west. Population II was located in Baxter County in north central Arkansas about 125 miles ENE of population I, one mile west of Mt. Home on highway 5.

Twenty-five plants in each population were sampled. Entire small plants or the top 30–40 cm. of large plants were pressed, and the height of each plant was recorded. Where less than the whole plant was collected, the individuals were tagged so that mature achenes could be harvested at a later visit. Plants were selected by walking through the population and collecting those of various heights at intervals of three steps (approximately 2 meters). A wide range in height was emphasized because it was noticed that relatively short and relatively tall plants appeared to differ significantly in phyllary number from the medium-sized plants in a single population.

The four key characters commonly used to separate the varieties (cf. Steyermark, 1963) were measured from the dried specimens: (1) number of outer phyllaries, (2) condition of their margins (degree of pubescence), (3) length of the outer and inner phyllaries, and (4) width of the inner and outer achenes. The varieties of *Bidens aristosa* (treated as species by Steyermark) are compared in the four key characters in Table I (extracted from Steyermark, 1963).

Table I. Differences between varieties of *Bidens aristosa*.

| Character | var. <i>aristosa</i> | var. <i>retrorsa</i> |
|--------------------------|---|---|
| No. outer phyllaries | 8–12 | 12–25 |
| Margins outer phyllaries | smooth or moderately finely hairy | coarsely hairy |
| Length outer phyllaries | 4–7 mm., mainly shorter than the inner phyllaries | 7–20 mm., mostly longer than the inner phyllaries |
| Mature achene width | outer: 3.3–5.2 mm. inner: 2.5–4.6 mm. | outer: 2.5–3.8 mm. inner: 1.8–2.8 mm. |

From earlier inspection it was known that phyllary number varied on different heads of the same plant. To see if the position of the head on the plant influenced phyllary number, the number of outer phyllaries was counted on several heads per individual. Counts of phyllary number were made on the terminal head of the main stem (T), the primary lateral head of the branch from the first node below the main terminal (L1), second node below the main terminal (L2) etc. through the fourth node (L4). Additionally, the phyllary number of the secondary lateral heads below each of the primary lateral heads (1a, 2a, 3a etc.) were counted; see Figure 1 for a diagram of these positions.

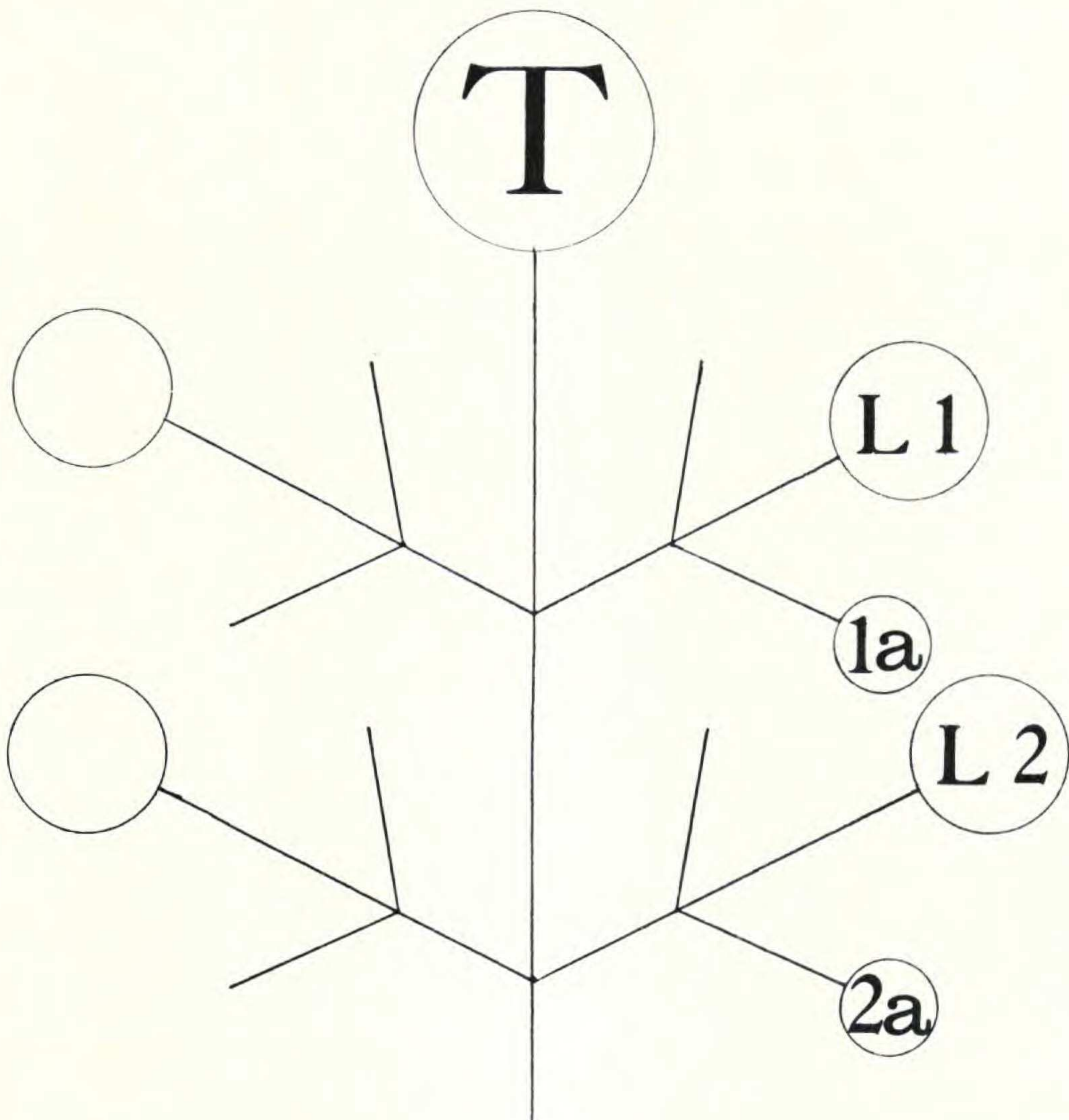


Figure 1. Schematic drawing of positions of heads measured in *Bidens aristosa* samples. T = main terminal; L1 = primary lateral head of node 1, L2 = primary lateral head of node 2, etc.; 1a = secondary lateral of node 1, 2a = secondary lateral of node 2, etc.

A scale of 1–5 was devised to rank the relative pubescence of the outer phyllaries of the plants (Figure 2). The lengths of the outer and inner phyllaries were converted to a ratio by dividing the outer length by the inner length. *Bidens aristosa* var. *aristosa* (outer phyllaries mainly shorter than inner) should exhibit a number of less than 1.0 under this scheme, while var. *retrorsa* (outer phyllaries mostly longer than inner) would exhibit numbers of greater than 1.0.

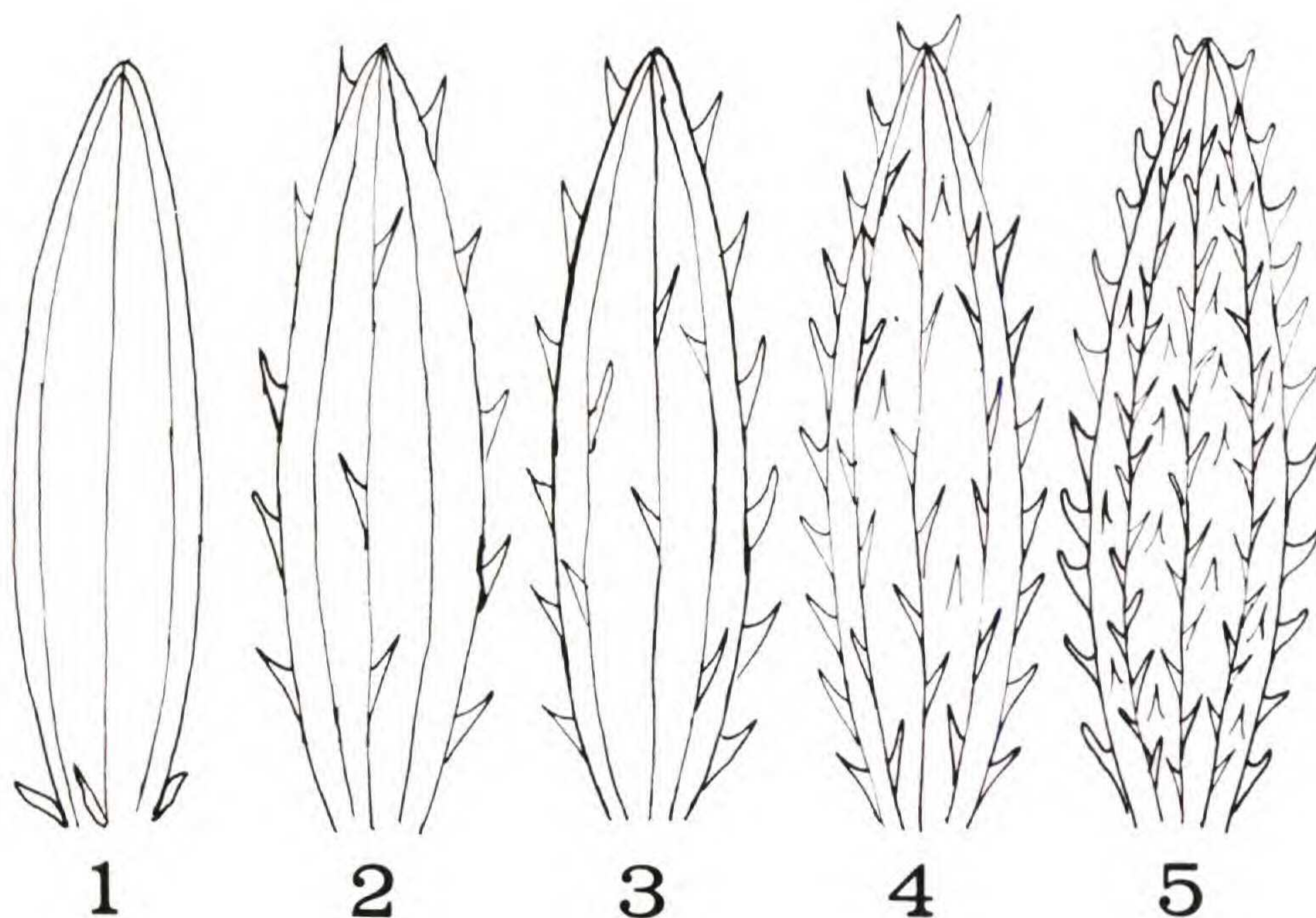


Figure 2. Scale of relative pubescence of the outer phyllaries in *Bidens aristosa* samples, from essentially glabrous (1) to densely hairy (5).

Specimens collected in the field for this study are on file at UARK. Herbarium specimens of *Bidens aristosa* (including those labeled *B. polylepis*) at UARK and SMU were examined for variation in the key characters.

RESULTS AND DISCUSSION

Tables II and III show the measurements of the four characters for populations I and II, which are listed according to height of the plants. When the height of the plant is compared with the number of outer phyllaries per head (Tables II & III), there is generally little correlation; but some positive correlation is exhibited on the extremes of the height range: plants less than 38 cm. tall (Table II) or more than 115 cm. tall (Table III) tend to have a decreased (very short) or increased (very tall) number of outer phyllaries. If one tends to pick up smaller plants that fit a press more evenly, one would generally be selecting plants with a smaller number of outer phyllaries; if one "top-snatched" larger plants, one would be unwittingly selecting plants with generally a larger number of outer phyllaries.

Table II. Height, outer phyllary pubescence & number per head, outer to inner phyllary ratio, and achene width of *Bidens aristosa* sampled from population I. (* = Unable to relocate in the field.)

| Plant No. | Height, cm. | Range, No. of outer phyllaries | Range, ratio O:1 phyllaries | Range of outer phyllary pubescence | Average width of inner achenes mm. | Average width of outer achenes mm. |
|-----------|-------------|-----------------------------------|--------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|
| 1 | 105 | 11-13 | 0.8-1.2 | 4-5 | 3.0 | 3.7 |
| 2 | 98 | 11-15 | 1.0 | 3 | 2.5 | 3.7 |
| 3 | 88 | 9-13 | 0.9-1.0 | 3 | 2.2 | 3.0 |
| 4 | 85 | 9-13 | 1.0-1.4 | 3 | 1.9 | 3.4 |
| 5 | 85 | 12-18 | 0.8-1.5 | 3-5 | 2.6 | 3.9 |
| 6 | 73 | 11-14 | 1.3-1.4 | 3-5 | * | * |
| 7 | 58 | 12-14 | 1.1-1.3 | 3-4 | 2.5 | 3.8 |
| 8 | 55 | 13-15 | 0.8-1.3 | 3-4 | 2.5 | 3.5 |
| 9 | 55 | 9-10 | 1.0-1.6 | 5 | 2.5 | 3.6 |
| 10 | 50 | 10-12 | 1.4-1.6 | 2-3 | 3.0 | 3.8 |
| 11 | 50 | 12-15 | 0.9-1.2 | 3-5 | 2.3 | 3.0 |
| 12 | 48 | 10-13 | 1.1 | 2-4 | 2.4 | 3.2 |
| 13 | 45 | 12-14 | 1.0-1.6 | 3-4 | * | * |
| 14 | 43 | 9-11 | 1.1-1.2 | 3-4 | 2.9 | 3.4 |
| 15 | 43 | 9-10 | 1.1-1.5 | 3 | 2.4 | 3.4 |
| 16 | 43 | 11-12 | 1.1-1.6 | 3 | 2.8 | 3.4 |
| 17 | 43 | 10-13 | 0.9-1.4 | 3 | 2.9 | 3.6 |
| 18 | 40 | 10-12 | 1.0-1.1 | 2-3 | 2.1 | 2.9 |
| 19 | 38 | 13 | 1.3-1.5 | 3 | 2.8 | 3.6 |
| 20 | 38 | 9-10 | 1.4-1.7 | 3 | 2.5 | 3.6 |
| 21 | 34 | 8 | 1.1-1.2 | 4 | 2.5 | 2.8 |
| 22 | 34 | 10-12 | 1.1-1.5 | 3 | 2.8 | 3.8 |
| 23 | 34 | 10-12 | 1.3-1.5 | 2-3 | * | * |
| 24 | 32 | 7-10 | 1.6-1.7 | 2-3 | * | * |
| 25 | 20 | 7-13 | 0.9-1.6 | 2-3 | 3.4 | 3.8 |

Table III. Height, outer phyllary pubescence & number per head, outer to inner phyllary ratio, and achene width of *Bidens aristosa* sampled from population II. (* = Unable to relocate in the field.)

| Plant No. | Height, cm. | Range, No. of outer phyllaries | Range, ratio O:I phyllaries | Range of outer phyllary pubescence | Average width of inner achenes mm. | Average width of outer achenes mm. |
|-----------|-------------|--------------------------------|-----------------------------|------------------------------------|------------------------------------|------------------------------------|
| 1 | 138 | 13-18 | 1.0-1.2 | 3-4 | * | * |
| 2 | 133 | 13-17 | 0.8-1.2 | 5 | 2.6 | 4.0 |
| 3 | 130 | 14-22 | 0.9-1.2 | 4-5 | 2.0 | 3.6 |
| 4 | 129 | 14-23 | 0.7-1.0 | 3-4 | 2.7 | 3.6 |
| 5 | 115 | 11-15 | 0.9-1.2 | 3-5 | 2.1 | 3.2 |
| 6 | 105 | 10-15 | 0.7-1.0 | 4-5 | 2.4 | 3.2 |
| 7 | 100 | 13-16 | 0.8-1.2 | 3-4 | 2.4 | 3.2 |
| 8 | 100 | 11-14 | 0.9-1.2 | 3-5 | 2.4 | 3.7 |
| 9 | 100 | 10-17 | 0.9-1.3 | 3-4 | 2.5 | 3.6 |
| 10 | 95 | 11-14 | 0.8-1.1 | 5 | 2.6 | 3.3 |
| 11 | 95 | 9-14 | 0.7-1.0 | 3-4 | 2.8 | 3.6 |
| 12 | 95 | 10-16 | 0.8-1.1 | 4-5 | 2.5 | 3.1 |
| 13 | 90 | 10-14 | 0.9-1.2 | 3-5 | 2.6 | 3.8 |
| 14 | 88 | 12-16 | 0.9-1.6 | 5 | 2.7 | 4.1 |
| 15 | 83 | 13-16 | 1.0-1.2 | 4-5 | * | * |
| 16 | 75 | 13-14 | 0.8-1.1 | 3-5 | * | * |
| 17 | 75 | 11-14 | 0.8-1.1 | 3-4 | 3.1 | 4.1 |
| 18 | 73 | 12-17 | 0.6-1.1 | 4-5 | 2.0 | 4.2 |
| 19 | 70 | 13-18 | 1.0-1.2 | 4-5 | 2.6 | 4.2 |
| 20 | 68 | 14-18 | 0.8-1.4 | 4-5 | 2.4 | 3.5 |
| 21 | 60 | 10-14 | 0.9-1.1 | 3-4 | 3.0 | 3.5 |
| 22 | 60 | 11-13 | 0.6-0.9 | 4 | 3.0 | 3.9 |
| 23 | 55 | 12-15 | 0.9-1.0 | 3-4 | 1.8 | 3.5 |
| 24 | 53 | 9-15 | 0.8-1.1 | 3-4 | 2.7 | 3.7 |
| 25 | 46 | 13 | 1.0-1.1 | 3 | 2.2 | 3.8 |

On the basis of the range in number of phyllaries on a single plant (Tables II & III), particular individuals in the Arkansas populations could be counted as either variety. Based on the outer phyllary number, some plants are all one variety, some plants all the other variety, and many could be counted as either variety. It is clear that there is considerable overlap in Arkansas material for this character and that it is therefore of little taxonomic value in separating the varieties in Arkansas.

The phyllary pubescence character is also of little taxonomic value in separating the varieties in Arkansas. While all phyllaries on a head are the same, those on other heads of the same plant can be more or less hairy (Tables II & III).

The ratio of outer phyllary length to inner phyllary length is variable on individual plants (Tables II & III). Some heads measured on the same plant had the outer phyllaries longer and others had the inner phyllaries longer. This character is so variable on a single plant that it cannot be used as a distinguishing characteristic for the varieties.

Achene width is not used in the various manuals as often as the other characters. It is probably just as well because the measurements overlap between the two varieties. Achene widths measured on the Arkansas populations mostly straddled the area of overlap.

Tables IV and V provide data that indicate that the number of outer phyllaries per head is correlated with position of the head on the plant. Frequently (particularly in population II; Table V), the head terminating the main stem has more phyllaries than any other head on the plant. This head is the first one to bloom. Later heads terminating lateral branches (primary laterals; L1, L2, etc.) were found to be about the same for outer phyllary number regardless of node position, but had fewer outer phyllaries as a group than the terminal head. Secondary laterals (1a, 2a, etc.) had a smaller number than primary laterals. Thus, a single plant (on the basis of outer phyllary number) could key to *Bidens aristosa* var. *retrorsa* or var. *aristosa* depending on whether one counted the terminal, primary lateral, or secondary lateral heads.

Data presented in Tables II–V indicate that all of the four characters commonly used to separate the two varieties are unstable or highly variable, and that there is copious intergradation

Table IV. Number of outer phyllaries per head at different positions on the plant, for the *Bidens aristosa* sample of population I. (Blank spaces represent undeveloped heads or heads damaged in pressing some individuals. The positions (T, T1, etc.) are explained in the text and illustrated in Figure 1.)

| | T | L1 | L2 | L3 | L4 | 1a | 2a | 3a | 4a | Total | N | Av. |
|-------|------|------|------|------|------|------|------|------|------|-------|---|------|
| 1 | 12 | 15 | 13 | 12 | 11 | 14 | 13 | 12 | 13 | 115 | 9 | 12.7 |
| 2 | 11 | 12 | | 12 | | 9 | | 13 | | 57 | 5 | 11.4 |
| 3 | | 12 | 12 | | | 15 | 14 | | | 53 | 4 | 13.2 |
| 4 | 8 | 8 | | | | | | | | 16 | 2 | 8.0 |
| 5 | 10 | | 12 | 11 | | | 10 | 10 | | 53 | 5 | 10.6 |
| 6 | 7 | | | 12 | 10 | 7 | | 13 | 9 | 58 | 6 | 9.6 |
| 7 | | 15 | | 15 | | 14 | | 13 | | 57 | 4 | 14.2 |
| 8 | 12 | 12 | | | 13 | 11 | | | 11 | 59 | 5 | 11.8 |
| 9 | | 13 | | 13 | | 12 | | 14 | | 52 | 4 | 13.0 |
| 10 | 18 | 15 | | 15 | | 12 | | 13 | | 73 | 5 | 14.6 |
| 11 | 9 | 11 | | | | | | 13 | | 33 | 3 | 10.0 |
| 12 | 10 | | 10 | | | | 12 | | | 32 | 3 | 10.6 |
| 13 | 10 | 13 | | | | 12 | | | | 35 | 3 | 11.6 |
| 14 | | 10 | | | | 9 | 11 | | | 30 | 3 | 10.0 |
| 15 | 9 | | | | | | 10 | 10 | | 29 | 3 | 9.6 |
| 16 | | 9 | 9 | | | 10 | | | | 28 | 3 | 9.3 |
| 17 | 12 | 11 | | | | | | | | 23 | 2 | 11.5 |
| 18 | 12 | 10 | 13 | | 11 | | 11 | | 10 | 67 | 6 | 11.1 |
| 19 | | 10 | 8 | | 7 | 9 | 8 | | 7 | 49 | 6 | 8.1 |
| 20 | 11 | 10 | | | | 10 | | 10 | | 41 | 4 | 10.2 |
| 21 | 10 | 11 | | | | | 9 | | | 30 | 3 | 10.0 |
| 22 | 13 | 13 | 13 | | | 13 | | | | 52 | 4 | 13.0 |
| 23 | 10 | | | 10 | 10 | | 12 | | 9 | 51 | 5 | 10.2 |
| 24 | 11 | 11 | 14 | | 11 | | | | 11 | 59 | 5 | 11.8 |
| 25 | 14 | | | 12 | 12 | 12 | | 12 | 11 | 72 | 6 | 12.0 |
| Total | 209 | 220 | 104 | 104 | 85 | 169 | 110 | 133 | 81 | | | |
| N | 19 | 19 | 9 | 9 | 8 | 15 | 10 | 11 | 8 | | | |
| Av. | 11.0 | 11.5 | 11.5 | 12.4 | 10.6 | 11.2 | 11.0 | 12.0 | 10.1 | | | |

Table V. Number of outer phyllaries per head at different positions on the plant, for the *Bidens aristosa* sample of population II. (Blank spaces represent undeveloped heads or heads damaged in pressing some individuals. The positions (T, T1, etc.) are explained in the text and illustrated in Figure 1).

| | T | L1 | L2 | L3 | L4 | 1a | 2a | 3a | 4a | Total | N | Av. |
|-------|------|------|------|------|------|------|------|------|------|-------|---|------|
| 1 | 18 | 16 | 14 | | | | 13 | | | 61 | 4 | 15.2 |
| 2 | 14 | 11 | 16 | 13 | 13 | | 13 | | 10 | 90 | 7 | 12.8 |
| 3 | 14 | 13 | 12 | 16 | 16 | | 14 | 13 | 13 | 111 | 8 | 13.8 |
| 4 | 22 | 17 | 16 | 16 | 15 | | 15 | 14 | | 115 | 7 | 16.4 |
| 5 | 13 | 15 | 13 | 13 | 13 | | 13 | 13 | 11 | 104 | 8 | 13.0 |
| 6 | 18 | 15 | 15 | 16 | 16 | | 14 | 14 | | 108 | 7 | 15.4 |
| 7 | 13 | 12 | 11 | 13 | 12 | | 11 | | | 72 | 6 | 12.0 |
| 8 | 12 | 15 | 13 | | | | | | | 40 | 3 | 13.3 |
| 9 | 11 | 10 | 10 | | | 9 | | | | 40 | 4 | 10.0 |
| 10 | 15 | 14 | 14 | 14 | 14 | 13 | 14 | 14 | 13 | 125 | 9 | 13.8 |
| 11 | 16 | 15 | 15 | | | 13 | 13 | | | 72 | 5 | 14.4 |
| 12 | 17 | 14 | 14 | 15 | 16 | 15 | 12 | 14 | 13 | 130 | 9 | 14.4 |
| 13 | 13 | 13 | 12 | 14 | 12 | 12 | 12 | 11 | 10 | 109 | 9 | 12.1 |
| 14 | 14 | 13 | 14 | 14 | | 12 | 10 | | | 77 | 6 | 12.8 |
| 15 | 13 | 14 | 13 | 13 | 13 | 12 | 12 | 11 | 12 | 113 | 9 | 12.5 |
| 16 | 14 | 15 | 13 | 10 | 15 | 11 | 15 | 11 | 11 | 115 | 9 | 12.7 |
| 17 | | 14 | | | | 11 | | | | 25 | 2 | 12.5 |
| 18 | 17 | 14 | 16 | 15 | 15 | 13 | 13 | 13 | | 116 | 8 | 14.5 |
| 19 | | 13 | | | | 13 | | | | 26 | 2 | 13.0 |
| 20 | 14 | 13 | 14 | 13 | | 15 | 16 | | | 85 | 6 | 14.1 |
| 21 | | 12 | 13 | 14 | | 9 | 10 | 10 | | 68 | 6 | 11.3 |
| 22 | 23 | 19 | 18 | 18 | | 15 | 15 | 14 | | 122 | 7 | 17.4 |
| 23 | 14 | 17 | | 15 | | 13 | 13 | 10 | | 82 | 6 | 13.6 |
| 24 | 14 | 13 | 13 | 14 | 13 | 13 | 13 | 14 | 14 | 121 | 9 | 13.4 |
| 25 | 14 | 14 | 13 | 12 | 12 | 13 | 13 | 11 | 11 | 113 | 9 | 12.5 |
| Total | 333 | 351 | 302 | 268 | 195 | 212 | 274 | 187 | 118 | | | |
| N | 22 | 25 | 22 | 19 | 14 | 17 | 21 | 15 | 15 | | | |
| Av. | 15.1 | 14.0 | 13.7 | 14.1 | 13.9 | 12.4 | 13.0 | 12.4 | 11.8 | | | |

of *Bidens aristosa* var. *aristosa* and var. *retrorsa* in northern Arkansas. Frequently in Arkansas material, certain plants are similar to var. *aristosa* in one or two characters and to var. *retrorsa* in the remaining characters. Inspection of herbarium material from Arkansas and Texas indicates that the intergradation is not limited to northern Arkansas, but is widespread. Although the field sampling in this study was limited to northern Arkansas, we believe that the results are applicable to the entire eastern United States range of the two varieties. The two varieties are separated in manuals for other areas (e.g., Radford et al., 1968; Fernald, 1950; Correll & Johnston, 1970) on some or all of the same characters as those found to be inconstant in this study. While this study was undertaken to provide formal supporting data for Wunderlin's reduction of *B. polylepis* to *B. aristosa* var. *retrorsa*, the copious intergradation of varieties *aristosa* and *retrorsa* in northern Arkansas (and probably elsewhere) and the inconstancy of the key characters even for different parts of the same plant have convinced us that we are dealing with a single taxonomic unit which at the varietal level is polymorphic in these four characteristics.

We propose that *Bidens aristosa* var. *retrorsa* be completely merged with *B. aristosa* proper. The morphology and nomenclature of this species would then be:

Bidens aristosa (Michx.) Britton, Bull. Torrey Bot. Club **20**: 281. 1893.

Achenes awned, the awns antrorsely barbed: forma **aristosa**.

Coreopsis aristosa Michx., Fl. Bor. Am. **2**: 140. 1803.

Coreopsis aristata Muhl. ex Willd., Sp. Pl. **3**: 2253. 1804.

Coreopsis aurea Lindl., Bot. Reg. pl. 1228. 1829.

Coreopsis involucrata Nutt., Jour. Acad. Phila. **7**: 74. 1834.

Diodonta involucrata (Nutt.) Nutt., Trans. Am. Phil. Soc. n.s. **7**: 361. 1841.

Diodonta aristosa (Michx.) Nutt., Trans. Am. Phil. Soc. n.s. **7**: 360. 1841.

Bidens involucrata (Nutt.) Britt., Bull. Torrey Bot. Club **20**: 281. 1893 (*non* Sch.-Bip., 1846, *nec* Phil., 1891).

Bidens polylepis Blake, Proc. Soc. Wash. **35**: 78. 1922.

Bidens polylepis Blake var. *typica* Sherff, Brittonia **6**: 339. 1948.

Bidens aristosa (Michx.) Britt. var. *retrorsa* (Sherff) Wunderlin forma *involucrata* (Nutt.) Wunderlin, Ann. Mo. Bot. Gard. **59**: 472. 1972.

Achenes awned, the awns retrorsely barbed: forma **fritcheyi** (Fern.) Wunderlin, Ann. Mo. Bot. Gard. **59**: 471. 1972.

- Bidens aristosa* (Michx.) Britt. var. *fritcheyi* Fern., Rhodora **15**: 78. 1913.
Bidens involucrata (Nutt.) Britt. var. *retrorsa* Sherff, Bot. Gaz. **76**: 160. 1923.
Bidens polylepis Blake var. *retrorsa* Sherff, Bot. Gaz. **80**: 386. 1925.
Bidens aristosa (Michx.) Britt. var. *retrorsa* (Sherff) Wunderlin, Ann. Mo. Bot. Gard. **59**: 472. 1972.

Achene awns absent or reduced to tiny stubs: forma **mutica** (Gray) Wunderlin, Ann. Mo. Bot. Gard. **59**: 471. 1972.

- Coreopsis aristosa* Michx. var. *mutica* Gray Man. Bot. ed. **5**: 260. 1867.
Bidens aristosa (Michx.) Britt. var. *mutica* (Gray) Gattinger ex Fern., Rhodora **15**: 78. 1913.

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